The Ordovician–Silurian boundary in Mauritania

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Synopsis

Three sections are described across the Ordovician–Silurian boundary in Mauritania, each bearing well-developed glacial deposits succeeded by graptolitic shales. In general, fossils of the latest Ordovician and earliest Silurian are absent, apart from the southeastern section between Aratane and Oualata, at a cliff in Hodh, where the *persculptus* and *atavus* Zones are recorded.

Introduction

Three areas in Mauritania (Fig. 1) shed some light on the question of the Ordovician–Silurian boundary; however, the pioneer stage of work in these large areas encourages caution. The areas are:

1 Zemmour Noir (northern Mauritania), known from the masterly contribution of Sougy (1964) and included in the northern flank of the Reguibat uplift in Deynoux *et al.* (1985).
2 The Mauritanian Adrar, monographed by Trompette (1973), in the western part of the Taoudeni Basin (Deynoux *et al.* 1985).
3 Hodh, whose Precambrian and Ordovician glacial deposits were studied by Deynoux (1980); this is in the eastern extension of Tagant, which reaches the Adrar towards the S and SE. The Hodh escarpment frames a Cambro–Ordovician–Silurian ribbon to the N of the southern margin of the Taoudeni Basin before the post-Palaeozoic oversteps it (Deynoux *et al.* 1985).

In each area, the glacial upper Ordovician has been carefully studied and these deposits are more remarkable than those of Morocco, since they were nearer to the Lower Palaeozoic pole, and so record even more glacial activity, and, moreover, the glacial episode lasted for a longer time. The Ordovician–Silurian relationships are very gradual at Hodh and marked by an acute change of facies at Adrar and Zemmour.

Regional descriptions

1 **Zemmour Noir** (Fig. 2A, but chiefly Deynoux *et al.* 1985: 347, fig. 4; 354, fig. 6; and 369, fig. 7). The upper Ordovician consists of the Garat el Hamoueid Group and overlies rocks of Precambrian to Llanvirn age. Its upper boundary is correlated with the upper Ashgill by analogy with comparable deposits in Morocco and Algeria and its thickness varies between 0 and 200 m. The rocks are typical glacial deposits but these characteristics become less clear to the NW in the Dhlou Chain because of tectonic complications. Some sedimentological features suggest a more periglacial regime near the top. Faunas are very rare and consist only of 'indeterminable *Camarotoechia*' compared by Havlíček (1971) with other brachiopods of the upper sandstones of the Deuxième Bani of Morocco; and of *Cornulites*.

The base of the Silurian is marked by a very sharp discontinuity, and the system is well developed on the eastern margin of Zemmour, striking SSW–NNE. It always starts with *Demirastrites triangulatus* (Harkness) (determined by A. Philippot) in a facies of black, argillaceous, and some micaceous, shales. Its thickness seems to decrease evenly from 30 m in the north to 6 m in the south.

Among the detailed sections of Sougy (1964), the more northern, west of Gara Bouya Ali, has its base concealed by about 27 m of sandy 'oued': in the 3 m of overlying shales there are specimens of *Monograptus sedgwickii* (Portlock) (determined by A. Philippot), while a 30 cm bed of sandstones separates the top of the Garat el Hamoueid Group from the hidden part.

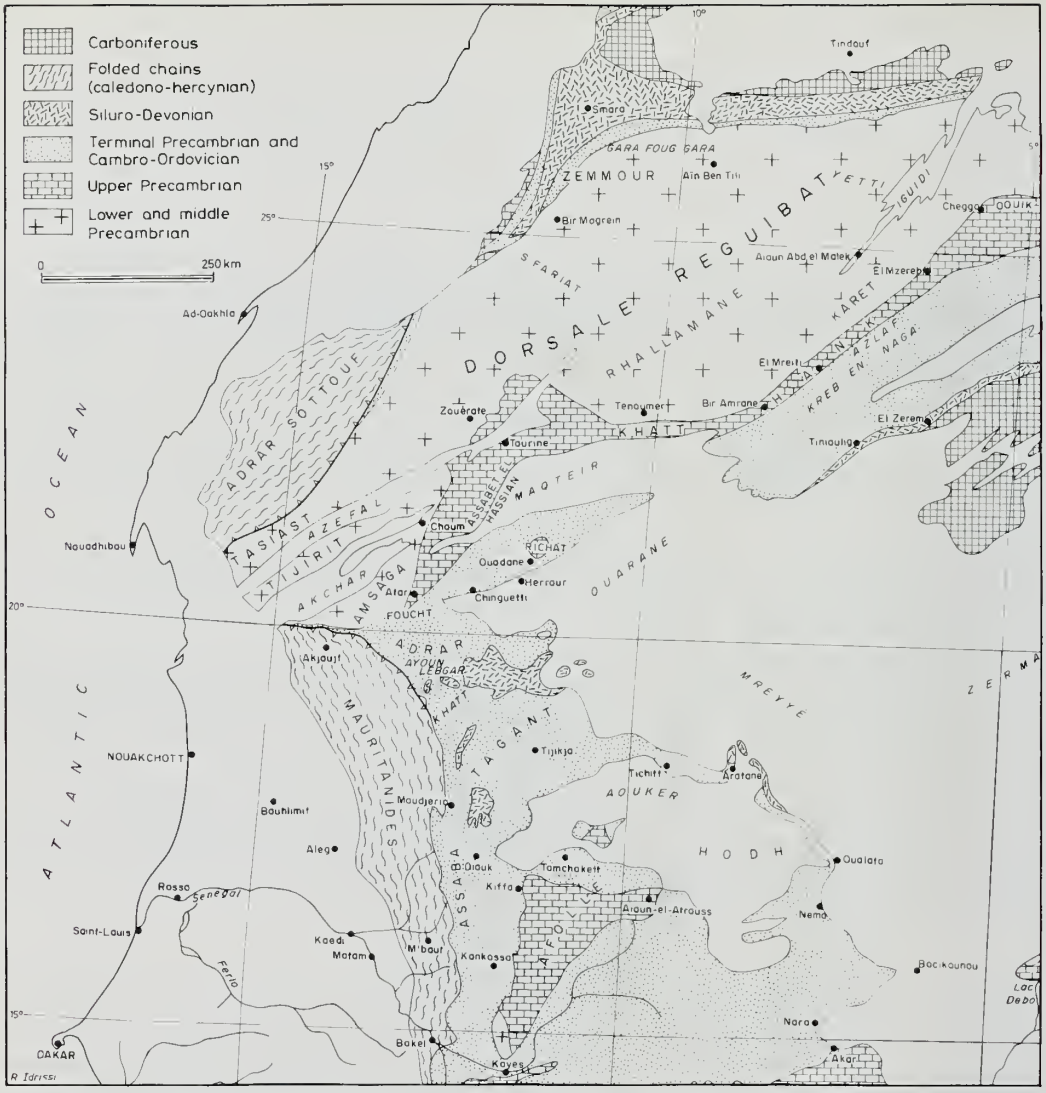

Fig. 1 Geological sketch of the western margin of the Taoudeni Basin, Mauritania, after Deynoux (1980).

Elsewhere, the surface of the sandstones at the contact with the shales is sometimes covered by a yellow coating. At Gara Foug Gara there is 2 m between '*Camarotoechia*' and *Demirastrites triangulatus*. There is therefore not much hope of defining the boundary exactly in Zemmour Noir, unless new discoveries are made in the western tectonized part. The Silurian has been noted in the Dhlou Chain but has not been systematically studied.

2 **The Mauritanian Adrar** (Fig. 2B, but chiefly Deynoux *et al.* 1985: 371, fig. 11; 374, fig. 12; 378, table 3). This area geomorphologically consists of (roughly from NNE to SSW), the Atar plain, the cliff, the plateaus (tabular zone) and the SW margin (folded zone), overlapped by the Mauritanides chain. The Ordovician–Silurian boundary is exposed in the two last units, but the area can be treated as a whole, whilst noting that the Silurian becomes more sandy to the

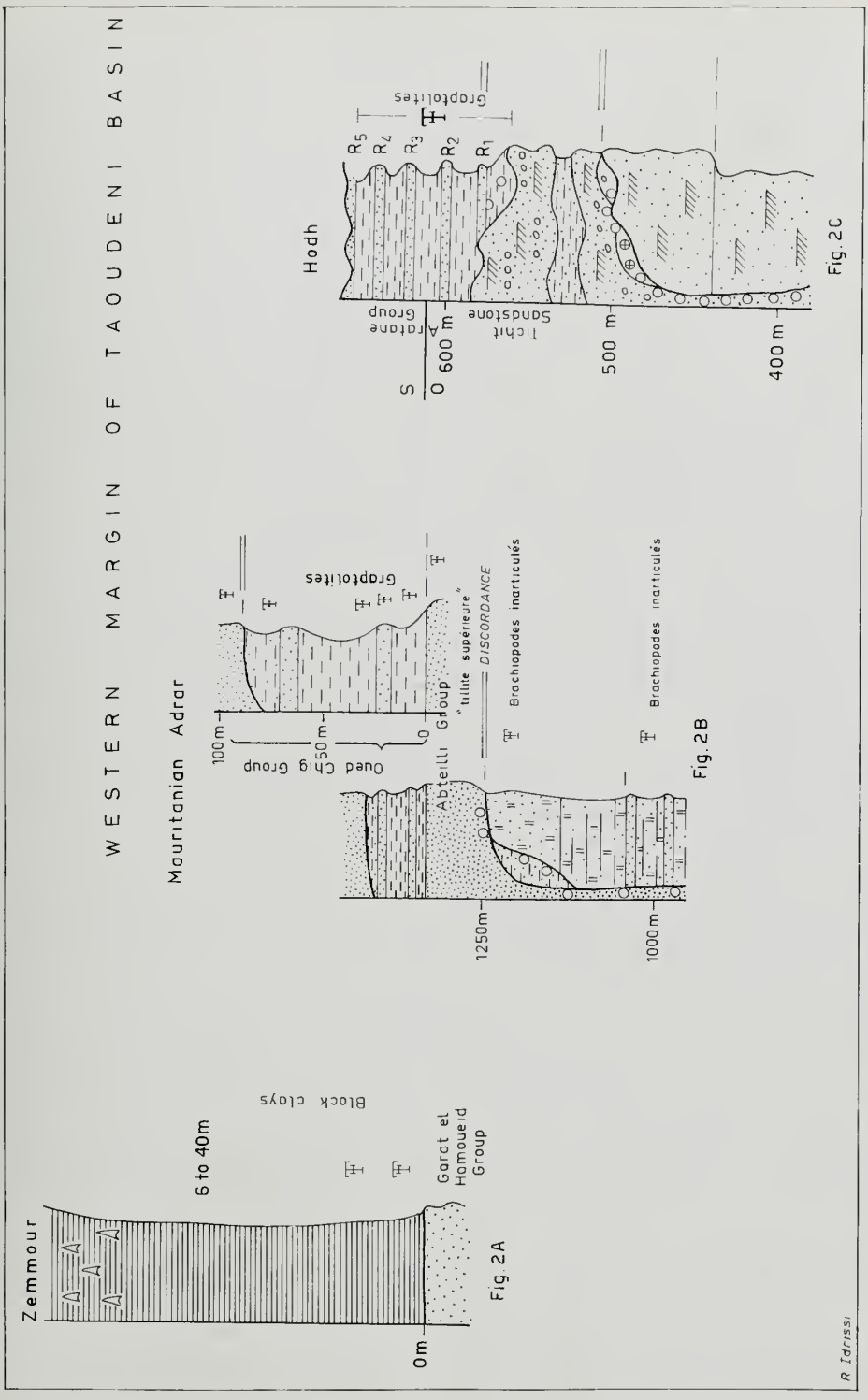

Fig. 2 Ordovician–Silurian boundary sections in Mauritania. The boundary is between R_2 and R_3 sandstones in the Hodh section (after Deynoux *et al.* 1985).

WSW. The glacial formation and the Silurian have been called 'Supergroup 3' by Trompette (1973), subdivided into the Abteilli Group and the Oued Chig Group.

(a) The Abteilli Group represents the glacial upper Ordovician whose lower boundary is difficult to establish because the glacial deposits occur in a landscape long exposed to continental deposition and weathering. The only earlier marine palaeontological horizon consists of lingulids of probable Cambro-Ordovician boundary age (determined by P. Legrand). The top of the group is marked by sandy eskers which reflect the withdrawal of the land ice to the south-east. At the time of Monod's survey (1952) in this district, some brachiopods in a sandstone from the folded zone at Ayoun Lebgar were determined by D. Le Maitre, who recognized the genera *Camarotoechia*, *Rhynchonella* (especially *R.* ex gr. *borealis*), *Orthis*, *Dalmanella* etc., but frequently with nomenclatural doubt. Monod thought that these sandstones were of Silurian age and that influenced the palaeontologist in her attribution to a high level in the Wenlock. However, these brachiopods may perhaps better be compared with those from Gara Foug Gara. J. Drot considers that in Zemmour as well as in Adrar all these fossils are indeterminable, but it is tempting to compare the total fauna directly. In the section, collected again by Trompette (1973), the usual graptolitic shales are immediately above the brachiopod-bearing lenticular sandstones, which indicate a marine incursion which might have been contemporaneous with those of Zemmour or the upper sandstones of the Deuxième Bani, and so Trompette has suggested that they belong to the lower Silurian. However, prudence is necessary with such weak data and both possibilities remain hypotheses.

(b) The base of the Oued Chig Group. In the fifteen sections and complementary support sections, Trompette (1973) was able to verify the concordance between the Abteilli Group and the Oued Chig Group and also the striking difference in sedimentation between the two groups. Their contact is rarely clear: there is often 1 m or more of sandy debris masking the extreme base of the Silurian. The oldest graptolites are: *Climacograptus normalis* Lapworth, *C.* cf. *rectangularis* (M'Coy), *C.* cf. *scalaris* (Hisinger), ?*C.* sp. or *Pseudoglyptograptus* sp., cf. *Pseudoclimacograptus* (*Metaclimacograptus*) *hughesi* (Nicholson), *Diplograptus magnus* Lapworth, *D. modestus* Lapworth or *D. magnus*, *Pristiograptus regularis* (Törnquist), *Lagarograptus tenuis* (Portlock), *M. sedgwickii* and ?*Cyclograptus* sp. or *Calyptograptus* sp. There is no *Akidograptus acuminatus* (Nicholson) but a part of the Rhuddanian may be present when the lowest association contains only the first *Climacograptus* and *Diplograptus* either *modestus* or *magnus*. In Adrar it appears that the Llandovery Series begins earlier than in Zemmour because of the scarcity of monograptids at the base.

3 **The Hodh** (Fig. 2c, but chiefly Deynoux *et al.* 1985: 389, fig. 16 and unpublished determinations). The subdivisions adopted here are Tichit Sandstones for the glacial formation and Aratane Group for the sandstones and shales with graptolites. The definition of the Ordovician–Silurian boundary (Cocks 1985) may modify somewhat the Silurian attribution of some of the basal graptolitic sediments.

The glacial complex rests on any formation among those defined as Cambro-Ordovician. The major erosional disconformity which opens the glacial cycle is perhaps also in places an angular unconformity, for example in Tagant (Dia *et al.* 1969). Deynoux (1980) has recognized a lower and an upper part in a total thickness of the order of 100–150 m. The upper part, with several members, includes sandstones and microconglomeratic clays underlying a landmark sandstone R_1, followed by sandy clays (still with microconglomeratic layers) under a second sandy landmark R_2, above which are the clays with graptolites of the Aratane Group. To the east there are further sandstones termed R_3 and R_4. This group ranges from 100–130 m in thickness.

In the more southeastern section, about halfway between Aratane and Oualata, a bed with graptolites between R_1 and R_2 contains some diplograptids identified as amplexograptids of Ashgill type. Following the escarpment to the north and west, the sandy landmarks become less easy to correlate but the zone of *Glyptograptus persculptus* is well represented:

(a) The more western layer, a portion of the Aratane cliff, appears to be deposited in a glacial gully under R_1 and contains only *Climacograptus normalis* and *C. transgrediens* Waern.

(b) The *persculptus* Zone contains: *Glyptograptus persculptus* (Salter), ?*Acanthograptus* sp. or ?*Koremagraptus* sp., *C. normalis*, *C. miserabilis* Elles & Wood, *C. transgrediens*, *C.* cf. *praemedius* Waern, *C. medius* (Törnquist), *C.* cf. *rectangularis*, *C.* cf. *indivisus* Davies, *C. minutus*? Elles & Wood, a more amplexograptid than climacograptid new form which recalls some figures of *Comatograptus* Obut & Sobolevskaya or *Hedrograptus* Obut, although more oval; rare fragments of *Orthograptus* ex gr. *truncatus* Lapworth, and ?*Akidograptus* sp. Some climacograptids show basal spines (Elles & Wood 1906; series of species of Manck 1924 (see Münch 1952); reminiscent of more ancient species such as those described by Ross & Berry, 1963). The septa of *G. persculptus* begins at the 4th theca.

These beds, except one, are in the portion of the Oualata-cliff, therefore to the NW–SE and above R_2 (but Deynoux cannot always decide between R_1 and R_2 towards the NW) in a facies of argillaceous shales and sandy layers and lenses, and some more micaceous beds.

(c) Above in the same member and in the portion of Oualata-cliff:

(i) A layer in a more sandy facies: *C. normalis*, *C. transgrediens*, *C. medius*, *C.* probably *praemedius*, the amplexograptid form, a proximal part of *Rhaphidograptus*?, a proximal part of *Akidograptus*? and some monograptid thecae.

(ii) In the same facies as (b): *C. normalis*, *C. miserabilis*, *C. minutus*, amplexograptid form narrower than those above, *Orthograptus truncatus abbreviatus* Elles & Wood, *Dimorphograptus* sp., *Pribylograptus incommodus* (Törnquist) and *Atavograptus* ex gr. *atavus* (Jones).

(iii) *C. normalis*, *C. miserabilis*, *Pseudoclimacograptus* (*Metaclimacograptus*) *hughesi* or *undulatus* (Kurck), *Diplograptus modestus*, *D. diminutus* Elles & Wood, and a single *Peiragraptus* or pathological specimen of *Diplograptus* sp.?

(d) The landmark bed R_3 is above these layers, except in one section where it has not been recognized (*C. normalis*, *P.* (*M.*) *hughesi*, *Dimorphograptus* cf. *confertus* Lapworth), and the same facies as (b) begins again with *C. normalis*, *C. rectangularis*, *P.* (*M.*) *hughesi* or *undulatus*, *D. modestus*, *Glyptograptus* ex gr. *tamariscus* (Nicholson), *G. tamariscus linearis*? Perner, *G.* either *angulatus* Packham or *distans* Packham, ?*Raphidograptus* sp., *A. atavus*, *A. strachani* Hutt & Rickards, *Lagarograptus acinaces*? (Törnquist), and *Coronograptus cyphus*? (Lapworth).

To the north of Aratane, beyond the post-Palaeozoic cover, towards Mejahouda and in the vicinity of Tinioulig, Sougy & Trompette (1976) have sampled the usual climacograptids, *D. modestus*, *Cystograptus vesiculosus* (Nicholson) and *A.* ex gr. *atavus*. All these graptolites are often irregularly flattened, preserved in iron oxides or with a fragile black pellicule. There is never an impression of fusellar tissue. Their deposit is rarely homogeneous along the rhabdosome. Some layers contain brachiopods and numbers of other organic fragments.

The Ordovician–Silurian boundary is therefore situated between the sandy landmarks R_2 and R_3 in the east of the Hodh. *G. persculptus* terminates the Ordovician, *A. acuminatus* is only suspected, and the remaining Rhuddanian is well represented. One should not forget that these collections are the first made systematically from this adverse environment, and reflect limited field-work, which was part of a large programme executed in a short time and with no possibility of immediate revision. The cliff at Hodh, in the Oualata area, if it were more accessible, would nevertheless be a first-rate place for a parastratotype, since it records the end of the African glacial phenomenon and has a good Ordovician–Silurian transition.

Recently, Legrand (1986) has described in detail (before the choice of the boundary) the lower Silurian at Oued in Djerane, Algeria, and has recognized new taxa. There is certainly some correlation between the Hoggar margin and the west of the Taoudeni Basin. However, before defining an 'African' fauna, it would be very useful to demonstrate with more certainty the effects of diagenesis on the preservation of graptolites, the more so because sections in proteic tissues have revealed the ability of the cortical layers to trap exogeneous particles. These extraneous particles could, of course, modify considerably any part of a rhabdosome.

Conclusions

From the Hodh to the Adrar, the post-glacial transgression would seem to have begun in the Ordovician and extended towards the west in the earliest Silurian, arriving later in the

Zemmour. The cliff to the north-west of Oualata is the best exposure of the local Ordovician–Silurian boundary, though it is still necessary to fully describe and figure the graptolites and complementary faunas from there.

References

Cocks, L. R. M. 1985. The Ordovician–Silurian boundary. *Episodes*, Ottawa, **8:** 98–100.

Deynoux, M. 1980. Les formations glaciaires du Précambrien terminal et de la fin de l'Ordovicien en Afrique de l'Ouest. Deux exemples de glaciation d'inlandsis sur une plate-forme stable. *Trav. Lab. Sci. Terre St Jérôme*, Marseille, (B) **17:** 1–315.

——, **Sougy, J. & Trompette, R.** 1985. Lower Palaeozoic Rocks of West Africa and the western part of Central Africa. *In* C. H. Holland (ed.), *Lower Palaeozic of north-western and west central Africa*: 337–495. London.

Dia, O., Sougy, J. & Trompette, R. 1969. Discordances de ravinement et discordance angulaire dans le Cambro-Ordovicien de la région de Méjéria (Tagant occidental, Mauritanie). *Bull. Soc. géol. Fr.*, Paris, (7) **11:** 207–221.

Elles, G. L. & Wood, E. M. R. 1901–18. A monograph of British Graptolites. *Palaeontogr. Soc.* (Monogr.), London. *m* + clxxi + 539 pp., 52 pls.

Havlíček, V. 1971. Brachiopodes de l'Ordovicien du Maroc. *Notes Mém. Serv. géol. Maroc*, Rabat, **230:** 1–135, pls 1–26.

Legrand, P. 1986. The lower Silurian graptolites of Oued In Djerane: a study of populations at the Ordovician–Silurian boundary. *Spec. Publs geol. Soc. Lond.* **20:** 145–153.

Manck, E. 1924. Grosskolonien von Climacograptus, Abdrücke von Zelltieren von Graptolithen. *Natur*, Leipzig, **16.**

Monod, T. 1952. L'Adrar mauritanien (Sahara occidental). Esquisse géologique. *Bull. Dir. Mines Afr. occ. fr.*, Dakar, **15.**

Münch, A. 1952. Die graptolithen aus dem Anstehenden Gotlandium Deutschlands und der Tschechoslowakei. *Geologica, Berl.* **7:** 1–157, pls 1–62.

Ross, R. J. & Berry, W. B. N. 1963. Ordovician Graptolites of the Basin Ranges in California, Nevada, Utah and Idaho. *Bull. U.S. geol. Surv.*, Washington, **1134:** 1–177.

Sougy, J. 1964. Les formations paléozoïques du Zemmour noir (Mauritanie septentrionale); étude stratigraphique, pétrographique et paléontologique. *Annls Fac. Sci. Univ. Dakar* **15:** 1–695.

Trompette, R. 1973. Le Précambrien supérieur et le Paléozoïque inférieur de l'Adrar de Mauritanie (bordure occidentale du bassin de Taoudeni, Afrique de l'Ouest). Un exemple de sédimentation de craton, étude stratigraphique et sédimentologique. *Trav. Lab. Sci. Terre St Jérôme*, Marseille, (B) **7:** 1–702.